

09-11-00

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UTILITY PATENT APPLICATION TRANSMITTAL

(For new Non-provisional applications under 37 CFR 1.53(b))

Attorney Docket No.: _____
 First Named Inventor: Herbert Parks Hartgrove
 Express Mail Label No. EL601559061US

Box PATENT APPLICATION
 Commissioner For Patents
 Washington, D.C. 20231

Sir:

Transmitted herewith for filing is a new utility patent application of inventor(s): **Herbert Parks Hartgrove**
 and entitled: **Abrasion Resistant And Drapeable Nonwoven Fabric.**

Application Elements:

- ☒ Specification containing 18 (eighteen) pages (preferred arrangement set forth below)
- Descriptive Title of the Invention
 - Cross-reference to related applications (if applicable)
 - Statement regarding Federally-sponsored Research & Development (if applicable)
 - Reference to Microfiche Appendix (if applicable);
 - Background of the Invention
 - Brief Summary of the Invention
 - Brief Description of the Drawings (if filed)
 - Detailed Description
 - Claim(s)
 - Abstract of the Disclosure
2. ☒ Drawings: 5 (five) Sheets of ☐ formal drawings ☒ informal drawings
3. ☒ Oath or Declaration
- a. ☐ An executed declaration or oath for the utility patent application including a power of attorney,
 - b. ☒ An unexecuted declaration or oath for the utility patent application including a power of attorney;
 - c. ☐ Copy from a prior application (37 CFR 1.63(d), for continuation/divisional with No. 16 completed. [Note No. 4 below.]).
 - i. ☐ Signed statement attached deleting inventor(s) named in the prior application (see 37 CFR 1.63(d)(2) and 1.33(b)).
4. ☐ **For CONTINUATION or DIVISIONAL Applications only:** The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 3c, is considered as being part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

5. ☐ Microfiche Computer Program (Appendix)
6. ☐ Nucleotide and/or Amino Acid Sequence submission, including:
- ☐ Computer readable copy,
 - ☐ Paper copy (identical to computer copy),
 - ☐ Statement verifying identity of above copies.

Accompanying Application Parts:

7. ☐ Assignment Papers (cover sheet, document(s) and requisite fee).
8. ☐ 37 CFR 3.73(b) Statement (where there is an assignee)
- ☐ Power of Attorney
9. ☐ English Translation document (if applicable)
10. ☒ Information Disclosure Statement (IDS), including PTO-1449
- ☒ Copies of IDS Citations
11. ☐ Preliminary Amendment
12. ☒ Return Postcard for PTO Mail Room Date Stamp (should be specifically itemized).
13. ☐ Small Entity Statement(s)
- ☐ Statement filed in prior application, status still proper and desired.
14. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed).
15. ☐ Other _____
16. ☐ **If Continuing Application**, check appropriate box and supply the requisite information below and in a preliminary amendment:
- ☐ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No. _____, filed _____.
- Prior application information: Examiner: _____ Group/Art Unit: _____

Fee Calculation

The filing fee has been calculated as shown below:

Small Entity						Large Entity	
For	No. Filed	No. Allowed	No. Extra	Rate	Fee	Rate	Fee
Basic Fee					\$345.00		\$690.00
Total Claims	22	- 20 =	2	x \$9.00	\$	x \$18.00	\$36.00
Indep. Claims	3	- 3 =	0	x \$39.00	\$	x \$78.00	\$
Multiple Dependent Claims Present				+ \$130.00	\$	+ \$260.00	\$
				TOTAL	\$	TOTAL	\$726.00

17. ☒ A check in the amount of \$ 736.00 to cover the filing fee is enclosed.
18. ☐ Please charge my Deposit Account No. 04-1644 in the amount of \$ _____.
19. ☒ The Commissioner is authorized to charge payment of the following amounts associated with this communication or credit any overpayment to Deposit Account No. 04-1644:
- ☒ Additional filing fees under 37 CFR 1.16 or deficiencies in remittances therefor.
 - ☒ Additional processing fees under 37 CFR 1.17 or deficiencies in remittances therefor.
 - ☒ **ONLY if applicant has partially paid** the patent issue fee under 37 C.F.R. §1.18, then the **deficiency** shall be charged to Deposit Account No. 04-1644, and the Commissioner is authorized to so charge the Deposit Account.

Date: September 8, 2000

Attorney's Signature _____

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CERTIFICATE OF MAILING BY EXPRESS MAIL

I hereby certify that this Utility Patent Application Transmittal, enclosed application, and any other documents referred to as enclosed herein, are being deposited in an envelope with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated below and addressed to Box PATENT APPLICATION, Commissioner for Patents, Washington, D.C. 20231.

Express Mail Label No.: EL601559061US

Date of Deposit: September 8, 2000

Typed/Printed Name of Person Signing: Clarence Townsend

Signature: *Clarence Townsend*

ABRASION RESISTANT AND DRAPEABLE NONWOVEN FABRIC

Technical Field

The present invention relates generally to methods of making nonwoven fabrics, and more particularly to a method of manufacturing a nonwoven fabric exhibiting improved physical characteristics while retaining aesthetic appeal, permitting use of the fabric in a wide variety of consumer applications.

Background Of The Invention

The production of conventional textile fabrics is known to be a complex, multi-step process. The production of fabrics from staple fibers begins with the carding process where the fibers are opened and aligned into a feed stock known as sliver. Several strands of sliver are then drawn multiple times on drawing frames to further align the fibers, blend, improve uniformity as well as reduce the diameter of the sliver. The drawn sliver is then fed into a roving frame to produce roving by further reducing its diameter as well as imparting a slight false twist. The roving is then fed into the spinning frame where it is spun into yarn. The yarns are next placed onto a winder where they are transferred into larger packages. The yarn is then ready to be used to create a fabric.

For a woven fabric, the yarns are designated for specific use as warp or fill yarns. The fill yarn packages (which run in the cross direction and are known as picks) are taken straight to the loom for weaving. The warp yarns (which run in the machine direction and are known as ends) must be further processed. The packages of warp yarns are used to build a warp beam. Here the packages are placed onto a warper which feeds multiple yarn ends onto the beam in a parallel array. The warp beam yarns are then run through a slasher where a water soluble sizing is applied to the yarns to stiffen them and improve abrasion resistance during the remainder of the weaving process. The yarns are wound onto a loom beam as they exit the slasher, which is then mounted onto the back of the loom. Here the warp and fill yarns are interwoven in a complex process to produce yardages of cloth.

In contrast, the production of nonwoven fabrics from staple fibers is known to be more efficient than traditional textile processes as the fabrics are produced directly from the carding process.

Nonwoven fabrics are suitable for use in a wide-variety of applications where the efficiency with which the fabrics can be manufactured provides a significant economic advantage for these fabrics versus traditional textiles. However, nonwoven fabrics have commonly been disadvantaged when fabric properties are compared, particularly in terms of surface abrasion, pilling and durability in multiple-use applications. Hydroentangled fabrics have been developed with improved properties, which are a result of the entanglement of the fibers or filaments in the fabric providing improved fabric integrity. Subsequent to entanglement, fabric durability can be further enhanced by the application of binder compositions and/or by thermal stabilization of the entangled fibrous matrix. However, the use of such means to obtain fabric durability come at the cost of a stiffer and less appealing fabric.

U.S. Patent No. 3,485,706, to Evans, hereby incorporated by reference, discloses processes for effecting hydroentanglement of nonwoven fabrics. More recently, hydroentanglement techniques have been developed which impart images or patterns to the entangled fabric by effecting hydroentanglement on three-dimensional image transfer devices. Such three-dimensional image transfer devices are disclosed in U.S. Patent No. 5,098,764, hereby incorporated by reference, with the use of such image transfer devices being desirable for providing a fabric with enhanced physical properties as well as an aesthetically pleasing appearance.

Heretofore, attempts have been made to develop nonwoven fabrics exhibiting the necessary aesthetic and physical properties. U.S. Patent No. 5,393,304, discloses a washable spunlaced nonwoven cloth, with this patent contemplating use of a PAE binder composition (polyamide-amine-epichlorohydrin) with inclusion of cotton fiber in the fibrous matrix.

U.S. Patent No. 3,988,343, discloses a nylon fabric treated with a mixture of acrylic polymer and latex binder with tinting pigments. U.S. Patent No. 5,874,159 contemplates providing a spunlaced fabric structure with durability by the provision of a bonding material in the form of a thermal plastic polymer, which may be provided in the form of a net, an apertured or punctured film, or molten drop form. The bonding material acts to join layers or laminations from which the fabric is formed.

For specific applications, a nonwoven fabric must exhibit a combination of specific physical characteristics. As an example, fabrics used in apparel should be soft and drapeable, yet withstand home laundering, and be resistant to abrasion (which can result in aesthetically displeasing fabric "pills"). Fabrics used in the fabrication of apparel must also exhibit sufficient strength, tear resistance, and colorfastness to ensure a reasonable life span for the end-use article. The physical performance of a fabric in terms of liquid handling, i.e. perspiration control, is of utmost concern when apparel fabricated from such fabric is to be worn for extended lengths of time. These are among the characteristics which have been identified as being desirable for apparel applications including outerwear, workwear, footwear, and the like.

U.S. Patent 5,478,635, discloses a knitted nylon fabric, necessary for abrasion resistance, being adhesively affixed to a nylon nonwoven fabric "reservoir". The construction of this laminate structure requires the knitting of nylon yarn followed by the application of polyurethane adhesive dissolved in a highly volatile solvent such as methylene chloride. U.S. Patent 4,941,884 is directed to a method of fabricating an abrasion resistant woven material having good aesthetics.

Notwithstanding various attempts in the prior art to develop a nonwoven fabric acceptable for apparel use applications, a need continues to exist for a nonwoven fabric exhibiting aesthetic appeal while obtaining requisite mechanical characteristics.

Summary of The Invention

5 In accordance with the present invention, a method of making a nonwoven fabric embodying the present invention includes the steps of providing a precursor web comprising a fibrous matrix. While use of staple length fibers is typical, the fibrous matrix may comprise substantially continuous filaments and combinations thereof. In a particularly preferred form, the fibrous matrix is carded and cross-lapped to form a precursor web. It is also preferred that the precursor web be subjected to pre-entangling on a foraminous forming surface prior to imaging and patterning.

10 The present method further contemplates the provision of a three-dimensional image transfer device having a movable imaging surface. In a typical configuration, the image transfer device may comprise a drum-like apparatus that is rotatable with respect to one or more hydroentangling manifolds.

15 The precursor web is advanced onto the imaging surface of the image transfer device so that the web moves together with the imaging surface. Hydroentanglement of the precursor web is effected to form an imaged and patterned fabric.

20 Subsequent to hydroentanglement, the imaged and patterned fabric may be subjected to one or more variety of post-entanglement treatments. Such treatments include application of a pre-dyeing finish, dyeing of the fabric by conventional textile dyeing methods, and optionally, a subsequent post-dyeing finish.

25 A further aspect of the present invention is directed to a method of forming a durable nonwoven fabric which exhibits an enhanced degree of softness and drapeability, while providing the necessary high resistance to tearing and abrasion, to facilitate use in a wide variety of applications. The fabric exhibits a high degree of absorbency, thus permitting its use in apparel applications in which the fabric can quickly and effectively remove moisture, thus improving wearer comfort.

30

A method of making the present durable nonwoven fabric comprises the steps of providing a precursor web that is subjected to hydroentangling. Polyester precursor webs, in either homogeneous form or formed as a blend with other polymeric and/or natural fibers, have been found to desirably yield soft hand and good fabric drapeability. The precursor web is formed into an imaged and patterned nonwoven fabric by hydroentanglement on a three-dimensional image transfer device. The image transfer device defines three-dimensional elements against which the precursor web is forced during hydroentangling, whereby the fibrous constituents of the web are imaged and patterned by movement into regions between the three-dimensional elements of the transfer device.

In the preferred form, the precursor web is hydroentangled on a foraminous surface prior to hydroentangling on the image transfer device. This pre-entangling of the precursor web acts to partially integrate the fibrous components of the web, but does not impart imaging and patterning as can be achieved through the use of the three-dimensional image transfer device.

Subsequent to hydroentangling, the imaged and patterned nonwoven fabric is treated with a pre-dye finish to lend further integrity to the fabric structure. The polymeric binder composition is selected to enhance durability characteristics of the fabric, while maintaining the desired softness and drapeability of the patterned and imaged fabric.

Other features and advantages of the present invention will become readily apparent from the following detailed description, the accompanying drawings, and the appended claims.

Brief Description of The Drawings

The invention will be more easily understood by a detailed explanation of the invention including drawings. Accordingly, drawings which are particularly suited for explaining the invention are attached herewith; however, it should be understood that such drawings are for explanation purposes only and are not necessarily to scale. The drawings are briefly described as follows:

FIGURE 1 is a diagrammatic view of an apparatus for manufacturing a durable nonwoven fabric, embodying the principles of the present invention; and

FIGURE 2 is a diagrammatic view of an apparatus for the application of a post-dye finish onto a nonwoven fabric, embodying the principles of the present invention; and

FIGURE 3 is a fragmentary top plan view of a three-dimensional image transfer device of the type used for practicing the present invention, referred to as "mini-herringbone", with approximate dimensions shown in millimeters;

FIGURE 3a is a cross-sectional view taken along lines A-A of FIGURE 3; and

FIGURE 4 is a fragmentary top plan view of a three-dimensional image transfer device of the type used for practicing the present invention, referred to as "octagons and squares", with approximate dimensions shown in millimeters; and

FIGURE 4a is a cross-sectional view taken along lines A-A of FIGURE 4; and

FIGURE 4b is a cross-sectional view taken along lines B-B of FIGURE 4; and

FIGURE 4c is an isometric view of three-dimensional image transfer device shown in FIGURE 4.

Detailed Description

While the present invention is susceptible of embodiment in various forms, there is shown in the drawings and will hereinafter be described a presently preferred embodiment of the invention, with the understanding that the present disclosure is to be considered as an exemplification of the invention, and is not intended to limit the invention to the specific embodiment illustrated.

In accordance with the present invention, a durable nonwoven fabric can be produced which can be employed in apparel applications, with the fabric exhibiting sufficient softness, drapeability, abrasion resistance, strength, and tear resistance, with colorfastness to light, crocking, and laundering. It has been

difficult to develop nonwoven fabrics which achieve the desired hand, drape, and pill resistance that is inherent in woven fabrics. Typically, nonwoven fabrics in the 3.0 to 6.0 ounces per square yard range exhibit bulkiness, which in turn detracts from the hand and drapeability of the fabric.

5 In the case where nonwoven fabrics are produced using staple length fibers, the fabric typically has a degree of exposed surface fibers that will abrade or "pill" if not sufficiently entangled, and/or not treated with the appropriate polymer chemistries subsequent to hydroentanglement. The present invention provides a finished fabric that can be conveniently cut, sewn, and packaged for
10 retail sale or utilized as a component in the fabrication of a more complex article. The cost associated with designing/weaving, fabric preparation, dyeing and finishing steps can be desirably reduced.

With reference to FIGURE 1, therein is illustrated an apparatus for practicing the present method for forming a nonwoven fabric. The fabric is
15 formed from a fibrous matrix preferably comprising staple length fibers, but it is within the purview of the present invention that different types of fibers, or fiber blends, and/or continuous filaments can be employed. The fibrous matrix is preferably carded and cross-lapped to form a precursor web, designated P. In current embodiments, the precursor web comprises both 100% staple length
20 polyester fibers and polyester/nylon staple length fiber blends.

FIGURE 1 illustrates a hydroentangling apparatus for forming nonwoven fabrics in accordance with the present invention. The apparatus includes a foraminous forming surface in the form of belt 12 upon which the precursor web P is positioned for pre-entangling by entangling manifold 14.

25 The entangling apparatus of FIGURE 1 further includes an imaging and patterning drum 18 comprising a three-dimensional image transfer device for effecting imaging and patterning of the lightly entangled precursor web. The image transfer device includes a moveable imaging surface which moves relative to a plurality of entangling manifolds 22 which act in cooperation with three-

dimensional elements defined by the imaging surface of the image transfer device to effect imaging and patterning of the fabric being formed.

5 Manufacture of a durable nonwoven fabric embodying the principles of the present invention is initiated by providing the precursor nonwoven web, preferably in the form of a 100% polyester or polyester blend. The use of the polyester desirably provides drape, which upon treatment with the specific binder formulation listed herein, results in a material with improved physical properties over the competitive 100% nylon material. During invention development, fibrous layer ratios varying from 100 percent polyester by weight 10 to 50 percent polyester/50 percent nylon by weight were produced and tested. Such blending of the layers in the precursor web was also found to yield aesthetically pleasing color variations due to the differential absorption of dyes during the dyeing steps.

EXAMPLES

Example 1

15 Using a forming apparatus as illustrated in FIGURE 1, a nonwoven fabric was made in accordance with the present invention by providing a precursor web comprising Type 54W polyester fiber, 1.1 denier by 2.0 inch staple length, as obtained from Wellman. The web had a basis weight of 2.0 ounces per square yard (plus or minus 7%). The precursor web was 100% carded and cross-lapped, with a draft ratio of 2.5 to 1. 20

The precursor web then received thereupon a 1.5 oz of air-randomized Type T200 Nylon, 1.8 denier by 2.0 staple length, as obtained from Du Pont. Prior to patterning and imaging of the precursor web, the web was entangled by 25 a series of entangling manifolds such as diagrammatically illustrated in FIGURE 1. FIGURE 1 illustrates disposition of precursor web P on a foraminous forming surface in the form of belt 12, with the web acted upon by an entangling manifolds 14. In the present examples, each of the entangling manifolds included 3 orifice strips each having 120 micron orifices spaced at 42.3 per inch,

with the manifolds successively operated at 100, 300, 800 and 800 psi , at a line speed of 50 feet per minute.

5 The entangling apparatus of FIGURE 1 further includes an imaging and patterning drum 18 comprising a three-dimensional image transfer device for effecting imaging and patterning of the now-entangled precursor web. The entangling apparatus includes a plurality of entangling manifolds 22 that act in cooperation with the three-dimensional image transfer device of drum 18 to effect patterning of the fabric. In the present example, the three entangling manifolds 22 were operated at 1900 psi, at a line speed which was the same as
10 that used during pre-entanglement.

The three-dimensional image transfer device of drum 24 was configured as a so-called octagon and square, as illustrated in FIGURES 4, 4a, 4b, and 4c.

15 Subsequent to patterned hydroentanglement, the fabric was dried on three consecutive steam cans at 300° F at 26, then received a substantially uniform application by dip and nip saturation of a pre-dye finish composition at application station 30. The web was then directed through a tenter apparatus 32, operated at 300°F.

20 In the present example, the pre-dye finish composition was applied at a line speed of 50 feet per minute, with a nip pressure of 40 psi and percent wet pick up of approximately 120%.

The pre-dye finish formulation, by weight percent of bath, was as follows:

Water	83.4%
Y30	0.1%
<i>(Y30 is a silicone-based defamer) As may be obtained from Down Corning of Michigan</i>	
Hystretch V29	16.0%
<i>(Hystretch is an elastomeric polymer emulsion) Registered to B.F. Goodrich of New York</i>	
Freecat 187	0.02%
<i>(Freecat is a chemical catalyst) Registered to Freedom Textile Chemicals Co. of North Carolina</i>	
Tween 20	0.2%
<i>(Tween is a wetting and dispersing agent) Registered to ICI Americas, Inc. of Delaware</i>	
Cymel 303	0.24%
<i>(Cymel is a melamine cross-linking resin) Registered to American Cyanamid Co. of New York</i>	

After pre-dye finish application and curing of the finish on the imaged nonwoven fabric, the resulting fabric was dyed. Various dyeing methods commonly known in the art are applicable including nip, pad, and jet, with the use of a jet apparatus and disperse dyes, as represented by U.S. 5,440,771 and U.S. 3,966,406, both hereby incorporated by reference, being most preferred.

Subsequent to dyeing of the imaged fabric, the fabric was dried on three consecutive steam cans at 300°F and rewound. The now dyed nonwoven fabric then received a substantially uniform application by dip and nip saturation, depicted in FIGURE 2, of a post-dye finish composition at application station 41. The post-dye finish composition was applied at a line speed of 50 feet per minute, with a nip pressure of 40 psi and percent wet pick up of approximately 120%.

The post-dye finish composition formulation, by weight percent of bath, was as follows:

Water	97.8%
RU40-350	2.0%
<i>(RU40-350 is a polycarbonate resin) As may be obtained from Stahl, USA of Massachusetts</i>	
XR-2569	0.2%
<i>(XR-2569 is a carbodimide crosslinker) As may be obtained from Stahl, USA of Massachusetts</i>	

The final fabric was dried on steam cans 42 at 300° F.

Example 2

A fabric as made in the manner described in Example 1, whereby in the alternative the polyester precursor web reduced to a basis weight of 1.75 ounce, being formed by carding and air-randomization. In place of the 1.8 denier nylon fiber, an air randomized 1.1 denier by 2.0 inch staple length Type T200 Nylon at a 1.5 ounce basis weight was used.

Example 3

A fabric as made in the manner described in EXAMPLE 1, whereby in the alternative, a 100% Type 54W polyester fiber, 1.1 denier by 2.0 inch staple length, was formed into a precursor web at a basis weight of 4.0 ounces per square yard (plus or minus 7%). In the present example, the entangling manifolds 22 were operated at 4500 psi, at a line speed of 50 feet per minute.

The three-dimensional image transfer device of drum 24 was configured as a so-called mini-herringbone, as illustrated in FIGURES 3 and 3a.

In the present example, the pre-dye finish composition was again applied at a line speed of 50 feet per minute, with a nip pressure of 40 psi and percent wet pick up of approximately 120%.

The pre-dye finish composition formulation, by weight percent of bath, was as follows:

Water	73.6%
Y30	0.1%
Tween 20	0.2%
Rhoplex TR934HS	15.0%
<i>(TR934HS is an acrylic/copolymer emulsion) Registered to Rhom & Haas Co. of Delaware</i>	
Rhoplex TR407	10.0%
<i>(TR407 is an acrylic/copolymer emulsion)</i>	
Ammonia	0.1%
Sancure 861	1.0%
<i>(Sancure is a water-based urethane resin) Registered to Sannor Industries, Inc. of Massachusetts</i>	

The following benchmarks have been established in connection with nonwoven fabrics, which exhibit the desired combination of durability, softness, abrasion resistance, etc., for certain apparel and home use applications.

Fabric Strength/Elongation	ASTM D5034
Absorbency - Capacity	ASTM D1117
Elmendorf Tear	ASTM D5734
Handle-o-meter	ASTM D2923
Stiffness - Cantilever Bend	ASTM D5732
Thermal Shrink	Specified Below
Fabric Weight	ASTM D3776
Martindale Abrasion Test	ASTM D4970
Colorfastness to Crocking	AATCC 8-1988

Thermal shrinkage is determined by initially cutting 11 inch by 11 inch square samples of the test fabric, the samples being taken at a minimum of 4

inches from the edge of the fabric roll. Indelible reference markings are directly indicated on the sample at a 1 inch increment from each corner, a 9 inch span being centrally located on each edge of the sample resulting. The samples are then placed in an operating convention style oven of which has obtained and is maintaining a 350°F temperature. The samples are incubated for 30 minutes. At the conclusion of the incubation period, the samples are removed and allowed to cool on a flat surface until the samples reach ambient temperature. Samples are remeasured against the said reference markings. The difference between the final measure and the initial measure is presented in the form of a percent change.

The test data in Table 1 shows that nonwoven fabrics approaching, meeting, or exceeding the various above-described benchmarks for fabric performance in general, and to commercially available products in specific, can be achieved with fabrics formed in accordance with the present invention. Fabrics having basis weights between about 2.0 ounces per square yard and 6.0 ounces per square yard are preferred, with fabrics having basis weights of about 3.0 ounces per square yard and 4.0 ounces per square yard being most preferred. Fabrics formed in accordance with the present invention are durable and drapeable, and are suitable for apparel applications.

From the foregoing, it will be observed that numerous modifications and variations can be affected without departing from the true spirit and scope of the novel concept of the present invention. It is to be understood that no limitation with respect to the specific embodiments illustrated herein is intended or should be inferred. The disclosure is intended to cover, by the appended claims, all such modifications as fall within the scope of the claims.

WHAT IS CLAIMED:

1. A method of making a durable nonwoven fabric comprising the steps of:

- a) providing a precursor web;
- b) providing a three-dimensional image transfer device;
- c) hydroentangling said precursor web on said image transfer device to form a patterned and imaged nonwoven fabric;

d) applying a pre-dye finish to said nonwoven fabric to impart high abrasion resistance, followed by curing of said pre-dye finish; and

- e) dyeing of said nonwoven fabric.

2. A method of making a durable nonwoven fabric as in claim 1, said precursor web comprising layers of polyester fibers.

3. A method of making a durable nonwoven fabric as in claim 1, said precursor web comprising layers of polyester and nylon fibers

4. A method of making a durable nonwoven fabric as in claim 1, said precursor web is hydroentangled on a foraminous surface prior to said step of hydroentangling said web on said image transfer device.

5. A method of making a durable nonwoven fabric as in claim 1, said pre-dye finish comprising a melamine cross-linking resin.

6. A method of making a durable nonwoven fabric as in claim 1, said fabric is dyed by the method selected from the group consisting of jet dyeing, pad dyeing, screen printing, transfer printing, and the combinations thereof.

7. A method of making a durable nonwoven fabric comprising the steps of:

- a) providing a precursor web;
- b) providing a three-dimensional image transfer device;
- c) hydroentangling said precursor web on said image transfer device to form a patterned and imaged nonwoven fabric;

d) applying a pre-dye finish to said nonwoven fabric to impart high abrasion resistance, followed by curing of said pre-dye finish;

- e) dyeing of said nonwoven fabric;
- f) applying a post-dye finish to said nonwoven fabric to impart high abrasion resistance, followed by curing of said post-dye finish.

8. A method of making a durable nonwoven fabric as in claim 7, said post-dye finish comprising a cross-linking resin.

9. A method of making a durable nonwoven fabric as in claim 8, said post-dye finish comprising a carbodimide cross-linking resin.

10. A method of making a durable nonwoven fabric as in claim 8, said post-dye finish comprising a polycarbonate cross-linking resin.

11. A method of making a durable nonwoven fabric as in claim 8, said post-dye finish comprising a mix of polycarbonate and carbodimide cross-linking resins.

12. A durable nonwoven fabric, comprising:

- a) a precursor web;
- b) said precursor web being imaged and patterned by hydroentanglement on a three-dimensional image transfer device to form a nonwoven fabric;
- c) said nonwoven fabric receiving a substantially uniform application of a pre-dye finish followed by a curing step;
- d) dyeing of said nonwoven fabric;
- e) the resulting nonwoven fabric exhibiting a Martindale Abrasion Value of at least 50,000 cycles, a combined drupe value of less than 2.45 grams force per gram fabric weight and a combined bend value of less than 0.42 milligram-centimeter per mil thickness.

13. A method of making a durable nonwoven fabric as in claim 12, said precursor web comprising layers of polyester fibers.

14. A method of making a durable nonwoven fabric as in claim 12, said precursor web comprising layers of polyester and nylon fibers

15. A durable nonwoven fabric as in claim 12, said nonwoven fabric exhibiting a final basis weight of between about 2.0 ounces and about 6.0 ounces.

16. A durable nonwoven fabric as in claim 12, said nonwoven fabric exhibiting a final basis weight of between about 3.0 ounces and about 4.0 ounces.

17. A durable nonwoven fabric as in claim 12, said nonwoven fabric exhibiting a color fastness under wet test conditions of at least 5.

18. A durable nonwoven fabric as in claim 12, said nonwoven fabric exhibiting a color fastness under dry test conditions of at least 5.

19. A durable nonwoven fabric as in claim 12, said nonwoven fabric exhibiting a combined Elmendorf tear value of at least about 32 grams force per gram fabric weight.

20. A durable nonwoven fabric as in claim 12, said nonwoven fabric exhibiting an absorbency of at least about 0.25 percent capacity per second per gram fabric weight.

21. A durable nonwoven fabric as in claim 12, said nonwoven fabric is further processed by receiving a substantially uniform application of a post-dye finish

22. A durable nonwoven fabric as in claim 12, said nowoven fabric is used in the fabrication of apparel.

ABSTRACT OF THE DISCLOSURE

A method of forming abrasion resistant nonwoven fabrics by hydroentanglement includes providing a precursor web. The precursor web is subjected to hydroentanglement on a three-dimensional image transfer device to create a patterned and imaged fabric. Treatment with an initial pre-dye finish enhances the integrity of the fabric, permitting the nonwoven to exhibit desired physical characteristics, including strength, durability, softness, and drapeability. The pre-dye finish treated nonwoven may then be dyed by means applicable to conventional wovens. A post-dye finish may then be applied to further enhance the performance of the nonwoven fabric.

TABLE 1

				Inventive Material			Commercial Material
Type				Sample 1	Sample 2	Sample 3	Cambrelle.RTM Of Cantex, Inc.
Weight			ounces /yard ²	3.83	3.59	5.95	3.49
Bulk			mils	34.3	34.0	50.3	24.5
STRIP	TENSILE	MD	lbs.	35.83	48.68	65.58	24.37
		CD		28.15	33.78	47.29	24.16
	Combined Tensile/gram			0.45	0.62	0.51	0.37
	ELONGATION	MD	%	58.95	49.84	54.35	40.28
		CD		94.65	71.99	78.28	39.93
GRAB	TENSILE	MD	lbs.	72.58	92.21	123.4	62.45
		CD		67.50	82.73	91.73	57.46
	Combined Tensile/gram			0.98	1.31	0.97	0.92
	ELONGATION	MD	%	59.59	49.88	49.76	40.79
		CD		100.3	74.1	75.55	40.13
Absorbency		CAP	%	672	748	Buoyant	529
		TIME	sec	19	15	Buoyant	166
		Absorbency/sec/gram fabric			0.25	0.37	
Color Fastness		WET		5	5	5	4.5
		DRY		5	5	5	4.5
Handle-O-Meter		MD	grams	111	116	370	302
		CD		52	77	172	96
		Combined gram force/gram fabric			1.14	1.45	2.45
Cantilever Bend		MD	mg-cm	8.8	8.5	10.6	9.7
		CD		5.7	6.3	7.1	6.9
		Bend/bulk			0.42	0.44	0.33
Thermal Shrink (250°F for 30 min)		MD	%	-3	1.7	-3	-4
		CD		-1.5	0	-5.3	-5
Elmendorf Tear		MD	grams	2331	2451	3417	1084
		CD		2209	3223	4269	1410
		Combined gram force/gram fabric			32	42	35
Martindale Abrasion			cycles	> 50,000	> 50,000	> 50,000	> 50,000

Fig. 1

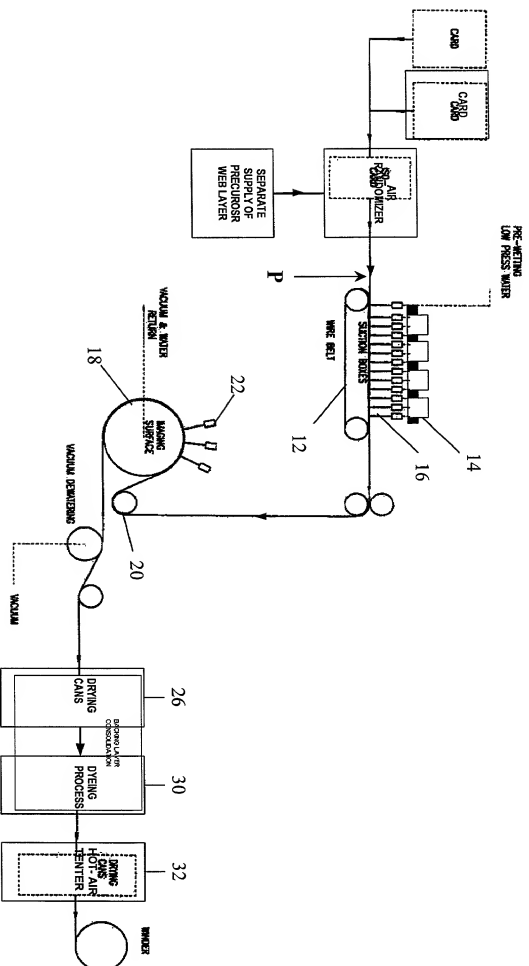


Fig. 2

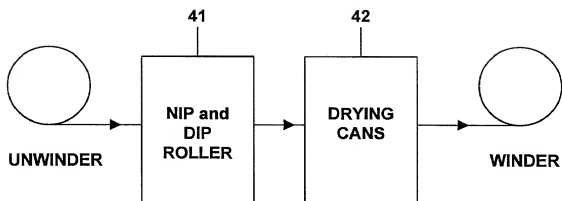


Fig. 3

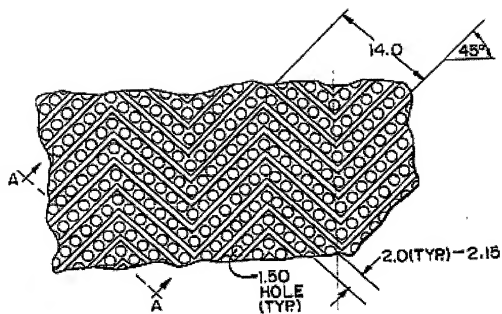


Figure 3a; SECTION A-A

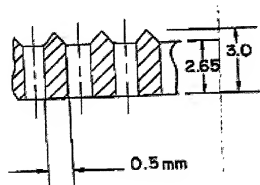


Figure 4

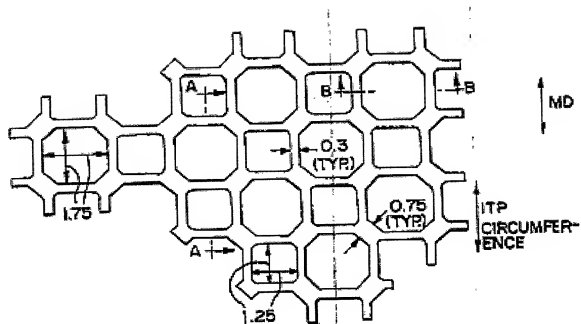


Figure 4a

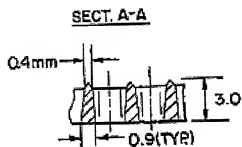


Figure 4b

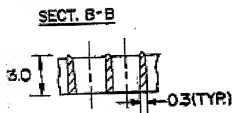
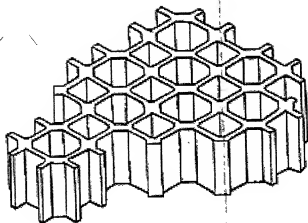


Figure 4c



<p align="center">DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)</p> <p><input type="checkbox"/> Declaration Submitted With Initial Filing <input type="checkbox"/> Declaration Submitted After Initial Filing (surcharge (37 CFR 1.16(a)) required)</p>		Attorney Docket No.:
		First Named Inventor: Herbert Parks Hartgrove
		<i>COMPLETE IF KNOWN</i>
		Application Number: Unassigned
		Filing Date:
		Group Art Unit:
		Examiner Name:

As a below-named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed) or an original, first, and joint inventor (if plural names are listed) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **Abrasion Resistant And Drapeable Nonwoven Fabric**, the specification of which:

- ☐ is attached hereto; or
- ☐ was filed on _____
as Application Serial No. _____
and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information to the Patent and Trademark Office known to me to be material to patentability of this application, as defined in 37 CFR. 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Numbers	Country	Foreign Filing Date	Priority Not Claimed	Certified Copy Attached?	
				YES	NO
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- ☐ Additional foreign application numbers are listed on a supplemental priority data sheet (PTO/SB/02B) attached hereto.

I hereby claim the benefit under 35 U.S.C. 119 (e) of any United States application(s) listed below.

Application Number(s)	Filing Date	<input type="checkbox"/> Additional provisional application numbers are listed on a supplemental priority data sheet (PTO/SB/02B) attached hereto.

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT International application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date	Parent Patent Number (if applicable)

☒ Additional U.S. or PCT International application numbers are listed on a supplemental priority data sheet (PTO/SB/02B) attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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Randall T. Erickson	Reg. No. 33,872	Robert B. Polit	Reg. No. 33,993
Stephen D. Geimer	Reg. No. 28,846	Elaine M. Ramesh	Reg. No. 43,032
Allen J. Hoover	Reg. No. 24,103	Keith V. Rockey	Reg. No. 24,713
Martin L. Katz	Reg. No. 25,011	John F. Rollins	Reg. No. 38,013
Kathleen A. Lyons	Reg. No. 31,852	Thomas I. Ross	Reg. No. 29,275
John P. Milnamow	Reg. No. 20,635	Joel E. Siegel	Reg. No. 25,440
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I hereby declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Signature:	Date:

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Citizenship:	
Residence:	
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